retaining the standard candle 48 inches off, on the left of the bar, the index is brought to zero by placing on the right

2 candles	67 in. off.
1 candle behind solution of sulphate of copper	6 "
" " alum plate	14 "
A small gas burner	113 "

These experiments show how conveniently and accurately this instrument can be used as a photometer. By balancing a standard candle on one side against any source of light on the other, the value of the latter in terms of a candle is readily shown; thus in the last experiment the standard candle 48 inches off is balanced by a gas-flame 113 inches off. The lights are therefore in the proportion of 48^2 to 113^2, or as 1 to $5\frac{1}{2}$. The gas-burner is therefore equal to $5\frac{1}{2}$ candles.

By interposing screens of water or plates of alum, and so cutting off the dark heat, the actual luminosity is measured. In addition to this, by interposing coloured glasses or solutions, any desired colours can be measured either against the total radiation from a candle, its luminous rays, or any desired colour. One coloured ray can be balanced against another coloured ray, by having differently coloured screens on either side.

The variations in the luminosity of a "standard" candle will cease to be of importance. Any candle may be taken; and if it be placed at such a distance from the apparatus that it will give a uniform deflection, say of 100 divisions, the standard can be reproduced at any subsequent time; and the burning of the candle may be tested during the photometric experiments by taking the deflection it causes from time to time, and altering its distance, if needed, to keep the deflection at 100 divisions.

If the pith bar in this instrument be blacked on alternate halves, an impetus given by a ray of light always acts in the same direction of movement. A candle causes it to spin round very rapidly until the suspending fibre is twisted up, and the rotation is stopped by the accumulated torsion.

By arranging the apparatus so that the black and white surfaces are suspended on a pivot instead of by a silk fibre, the interfering action of torsion is removed, and the instrument will rotate continuously under the influence of radiation. To this instrument the author has given the name of the "Radiometer." It consists of four arms of very fine glass, supported in the centre by a needle-point, and having at the extremities thin discs of pith lamp-blacked on one side, the black surfaces all facing the same way. The needle stands in a glass cup, and the arms and discs are delicately balanced so as to revolve with the slighest impetus.

In the "Proceedings of the Royal Society" last year, the author gave a brief account of some of the earlier experiments with these instruments. In the present paper he enters very fully into the various phenomena presented by them, and gives Tables showing the number of revolutions made by the radiometer when exposed to a constant source of light removed different distances from the instrument. The law is that the rapidity of revolution is inversely as the square of the difference between the light and the instrument.

When exposed to different numbers of candles at the same distance off, the number of revolutions in a given time are in proportion to the number of candles, two candles giving twice the rapidity of one candle, and three, three times, &c.

The position of the light in the horizontal plane of the instrument is of no consequence, provided the distance is not altered; thus two candles, one foot off, give the same number of revolutions per second, whether they are side by side or opposite to each other. From this it follows that if the radiometer is brought into a uniformly lighted space it will continue to revolve. This is proved to be the case by experiment.

The speed with which a sensitive radiometer will revolve in full sunshine is almost incredible. Nothing is visible but an undefined nebulous ring, which becomes at times almost invisible. The number of revolutions per second cannot be counted, but it must be several hundreds, for one candle will make it spin round forty times a second.

The action of dark heat (*i.e.*, from boiling water) is to repel each surface equally, and the movement of the radiometer is therefore arrested if a flask of boiling water is brought near it. The same effect is produced by ice.

From some observations made by the author, it appears probable that heat of a still lower refrangibility repels the white more than it does the black surface. Many instances are given of the radiometer revolving the reverse way. Thus, breathing gently on the instrument will generally cause this effect to be produced.

An experiment is described with a radiometer, the moving parts of which are of aluminium, blacked on one side. When exposed to the radiation from a candle, the arms revolve the normal way. On removing the candle they revolve the reverse way. Heated with a Bunsen burner the arms revolve the normal way as they are getting hot, but as soon as the source of heat is removed and cooling commences, rotation sets up in the reverse way, and continues with great energy till the whole is cold. It appears as if the reverse movement during the cooling is equal in energy to the normal movement as it is being heated.

It is easy to get rotation in a radiometer without having the surfaces of the discs differently coloured. An experiment is described with one having the pith discs blacked on both sides. On bringing a candle near it, and shading the light from one side, rapid rotation is produced, which is at once altered in direction by moving the shade to the other side.

The author describes many forms of radiometer, by means of which the movements can be exhibited to a large audience, or can be made to record themselves telegraphically on a self-recording instrument.

THE WATER SUPPLY OF THE METROPOLIS

IN the concluding portion of his anniversary address printed in the last number of NATURE (p. 376), the late president of the Geological Society severely criticises the proposal of the Rivers Commissioners to supply London with pure spring water. The Commissioners advise that the drinking water of London should continue to be derived from its present sources, but that it should be led away to its destination before it is mixed with the sewage of Oxford, Reading, Windsor, and other towns, and before it is fouled by the filthy discharges of paper mills and by other disgusting refuse.

Mr. John Evans thinks that it can hardly be believed that such a proposal as this should have been brought forward, involving, as he believes it would, if carried out, the conversion of the "fertile meadows" of the Thames Valley into "arid wastes," and the utter destruction of "watercress beds, now of fabulous value;" he adds that "even the canals and navigable rivers will become liable to sink and be lost in their beds." In predicting these dire results, he doubts whether his "judgment is *seriously* distorted," although he admits being deeply interested in the water power of one of the threatened valleys, and protests that no one can submit silently to an insidious (?) attack upon his property.

Having carefully studied for many years the hydrographical features of the Thames and other valleys, I have no hesitation in saying that Mr. Evans's fears are, for the most part, entirely unsupported by experience. Sterility

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of surrounding land has not accompanied the withdrawal of vast volumes of water from the deep wells at Deptford, Thames Head, Caterham, Canterbury, Watford, Tring, or Lichfield, and it is singular that Mr. Evans should have overlooked the fact that moisture is supplied to growing plants from above and not from below. However numerous the wells of a given district may be, the rain must still fall upon the surface of, and soak through, the land before it can reach them.

As the *dry-weather* flow of the Thames even above Teddington lock is 600 millions of gallons daily, it would be waste of time to discuss seriously the possibility of canals and navigable rivers sinking into their beds in consequence of the abstraction of about one-eighth of that volume from springs and deep wells in that portion of the river basin. With regard to the water-cress interest, it is true that the Rivers Commissioners have not been so deeply impressed as Mr. Evans with the stupendous importance of this department of Thames agriculture, but it can scarcely be doubted that a wealthy city, containing 4,000,000 of inhabitants, would be able and willing to pay for any damage which it might inflict upon this or any other branch of industry.

The two most disgusting impurities revealed by the microscope in Thames water, as delivered for dietetic purposes in London, are the fibres of partially digested flesh meat, and those of variously coloured rags. The presence of these objects in our potable water clearly indicates the two chief kinds of *insoluble* polluting matter cast into the Thames, although chemical analysis cannot always trace to its sources the *dissolved* animal and vegetable impurities which it finds accompanying these insoluble materials. The question raised, therefore, is simple enough :—Shall the inhabitants of this "overgrown city," as Mr Evans contemptuously terms it, drink the pure spring water which nature offers them in singular abundance in the Thames valley, or shall they not be permitted to taste this sparkling beverage until the paper manufacturers, in the exercise of what they call their rights, have washed their filthy rags in it, and half a million of people have polluted it by their drainage?

It is remarkable that whilst Mr. Evans shows so much consideration, in his presidential address, for the pockets of the watercress-growers, he has so little to bestow upon the inhabitants of the overgrown city, for he does not hesitate to propose that the latter should encounter the expense of two separate water services—one (pure) for dietetic, and a second (polluted) for other domestic purposes. Now, leaving out of consideration altogether the risk of the polluted water being often used for dietetic purposes instead of the pure, and the enormous cost and inconvenience of laying and maintaining a new set of water-mains throughout the hundreds of miles of London streets ; the supply of each house with a new water service, together with the necessary alterations of the old pipes, could not cost, on the average, less than 4*l.* In February last 523,801 houses were supplied with water by the eight metropolitan companies, and we have consequently here an expense of more than 2,000,000*l.* Surely a very small fraction of this sum would suffice to buy up any injured watercress-growers, even at "fabulous" prices.

In their sixth report, the Rivers Commissioners of 1868 state that the basin of the Thames, including that of its tributary, the Lea, is upwards of 5,000 square miles in extent. Rather more than one half of this area, including the oolitic and cretaceous formations, is covered by a porous soil upon a permeable water-bearing stratum, the remainder being occupied by the Oxford, Kimmeridge, gault, and London clays. The annual rainfall of this district averages about 28 inches, or 5,217 millions of gallons per day. Two-thirds of this vast volume of water is lost by evaporation, while, of the remaining one-third, one-half passes away in floods, and the other half only is at present available for springs and deep wells. But even this small fraction amounts to 870 millions of gallons daily, and it is proposed to take for the supply of the metropolis only 120 millions of gallons after it has practically performed all its fertilising functions ; whilst, of this volume, there is even now supplied to London, in dry weather, about twenty-two millions of gallons. It is highly probable, however, that the volume of water available at present for springs and deep wells could be augmented to an extent commensurate, or nearly so, with the amount so abstracted for the supply of London. The chalk, and to some extent the oolite of the Thames basin, constitute an immense sponge which sops up the water falling upon it and maintains it, partly by capillary attraction and partly by its resistance to flow, at considerable elevations above the nearest rivers. This sponge has been aptly likened by Mr. Thornhill Harrison to an inverted reservoir, and just as the dry-weather flow of the Thames and its tributaries could be augmented by the judicious use of artificial storage reservoirs, so could the total yield of spring water from this vast natural reservoir be increased, by artificially bringing the water in it to a lower level before the occurrence of the autumn and winter floods. The spongy reservoir would thus be rendered capable of receiving those heavy rainfalls which, at present unable to find storage room below, either run off the saturated surface and constitute the winter floods, or immediately displace a corresponding volume of spring water from the sponge forcing it into the Thames and its affluents.

In the concluding paragraphs of his address Mr. Evans tries to show, from the results of chemical analysis, that the polluted water of the Thames is purer than the spring water from the chalk, and he thus seeks to make the inhabitants of the metropolis content with their present supply. His statements on this subject are founded upon an entire misconception of the meaning of the analytical results. A most exhaustive chemical examination of the river waters of the Thames basin, on the one hand, and of the spring and deep-well waters on the other, has shown, in the most unmistakable manner, the immense superiority of the latter for dietetic purposes. Indeed, it is obvious that, even with the most efficient river conservancy imaginable, aided by the best efforts of the Legislature, the Thames must always receive so much pollution as to render its use for the supply of the metropolis highly objectionable. No preventive measures can hinder the washings of highly-manured land, the excrements of cattle, the imperfectly purified sewage of towns and villages, and the partially cleansed discharges from paper-mills, skinneries, and tanyards, from mingling with the stream in enormous volumes. Such matters, though not obviously offensive to the senses (when this highest practical stage of purification has been reached), are still, from a sanitary point of view, of a very dangerous character. But even if this were not so, and if fatal results had never been known to follow the domestic use of such water, the refined feeling which separates the civilised man from the savage, and which excites loathing at the bare idea of organic matter, which has recently formed part of a human body, being supplied for human consumption, ought here to assert itself, and secure the rejection of such a beverage.

E. FRANKLAND

SCIENTIFIC NOTES TAKEN IN THE HIMALAYAS

I.—*Atmospheric Absorption.*

THE following notes refer chiefly to spectroscopic work, and they are, I think, of interest, as they show the importance of establishing a regular series of similar observations at different points of the globe.

Prof. Vogel has lately published in Poggendorff's *Annalen* the results of his observations taken in the Red Sea and in the Indian Ocean. He comes to the

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